(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 782 936 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
09.07.1997 Bulletin 1997/28

(21) Application number: **96309413.1**

(22) Date of filing: **23.12.1996**

(51) Int. Cl.[6]: **B60C 11/00**, B60C 11/03, B60C 11/04

(84) Designated Contracting States:
DE FR GB

(30) Priority: **29.12.1995 JP 353094/95**

(71) Applicant: **Sumitomo Rubber Industries Limited**
Kobe-shi, Hyogo-ken (JP)

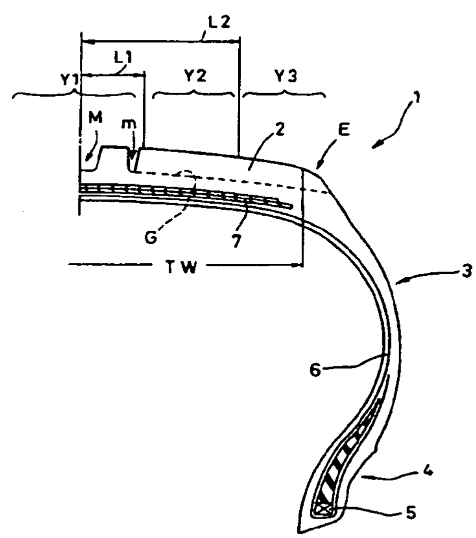
(72) Inventor: **Uemura, Yoshiaki**
Kobe-shi, Hyogo-ken (JP)

(74) Representative: **Stewart, Charles Geoffrey**
SP TYRES UK LIMITED
Technical Division
Fort Dunlop, Erdington, Birmingham B24 9QT
(GB)

(54) **Pneumatic tyre**

(57) A pneumatic tyre with an improved tread portion having reduced pass-by noise with improved wet performances, wherein a central region Y1 of the tread between a pair of first circumferential lines X1 is provided with a wide circumferential groove (M) having a width W1 of from 0.05 to 0.15 times the ground contacting width TW; a pair of middle regions Y2 between the first circumferential lines X1 and second circumferential lines X2 and a pair of shoulder regions Y3 axially outward of the second circumferential lines X2 have no circumferential groove but axial grooves (G), the axial grooves (G) extending from the central region Y1 to the tread edges (E) and intersect the first circumferential lines X1 at an angle θ1 of from 10 to 25 degrees and the second circumferential lines X2 at an angle θ2 of from 30 to 45 degrees; and each first circumferential line X1 on each side of the tyre equator (C) is at an axial distance L1 of 0.1 to 0.15 times the width TW, and each second circumferential lines X2 on each side of the tyre equator (C) is at an axial distance L2 of from 0.325 to 0.375 times the width TW.

Fig. 1



EP 0 782 936 A1

Printed by Rank Xerox (UK) Business Services
2.14.8/3.4

Description

The present invention relates to a pneumatic tyre with an improved tread region capable of reducing pass-by noise and improving wet performances.

Recently, as noise from car mechanisms especially gasoline engines is remarkably reduced, the demand for a silent tyre is becoming very strong. From an environmental viewpoint, it is effective to reduce the so called pass-by noise, a main cause of which is air tube resonance sound in a frequency range of 0.8 to 1.0 Hz. This is caused by any wide circumferential groove in the ground contacting patch of the tyre acting with the ground surface to form an air tube. A resonance occurs during running, and the resonance sound leaks through axial grooves connected to the circumferential groove and is heard as a noise.

It is known that the air tube resonance sound can be reduced by decreasing the width of a circumferential groove and/or the number of circumferential grooves in the tread.

Such countermeasures however, decrease drainage under wet conditions. Thus the wet performance factors of the tyre are inevitably deteriorated.

It is therefore, an object of the present invention to provide to a pneumatic tyre in which the above-mentioned contradictory problems can be solved, that is, pass-by noise is reduced and drainage is improved.

According to one aspect of the present invention, a pneumatic tyre comprises a tread portion having a ground contacting width TW, provided in a central region Y1 with a wide circumferential groove having a groove width W1 of from 0.05 to 0.15 times the ground contacting width TW and extending continuously in the tyre circumferential direction, where the central region Y1 is defined as being between a pair of first circumferential lines X1 one drawn on each side of the tyre equator at an axial distance L1 from the tyre equator of 0.1 to 0.15 times the ground contacting width TW, wherein the tread portion is not provided either in the middle regions Y2 or in the shoulder regions Y3 with a circumferential continuously extending groove, but a plurality of axial grooves each extending from the central region Y1 through one of the middle regions Y2 and one of the shoulder regions Y3 to one of tread edges, the axial grooves having a groove width W2 of from 0.02 to 0.035 times the ground contacting width TW, the middle regions Y2 being defined as between the first circumferential lines X1 and a pair of second circumferential lines X2 one drawn on each side of the tyre equator at an axial distance L2 from the tyre equator C of from 0.325 to 0.375 times the ground contacting width TW, the shoulder regions Y3 each being defined as extending axially outwardly from each of the second circumferential lines X2, and the axial grooves intersect the first circumferential lines X1 at an angle $\theta 1$ of from 10 to 25 degrees, and intersect the second circumferential lines X2 at an angle $\theta 2$ of from 30 to 45 degrees.

Preferably, the middle regions Y2 are provided with sipes having a width of not more than 1.5 mm, wherein, in each region which is surround by the circumferentially adjacent axial grooves G and the first and second circumferential lines X1 and X2, the total LC of the circumferential components of all the sipes therein, the total LW of the axial components thereof, and the ground contacting width TW satisfy: $0.7 \leq (LC+LW)/TW \leq 1.2$.

Embodiments of the present invention will now be described in detail in conjunction with the accompanying drawings, in which:

Fig.1 is a cross sectional view of a tyre according to the present invention showing an example of the tyre internal structure;
Fig.2 is a partial plan view thereof showing an example of the tread pattern;
Fig.3 is an enlarged plan view showing another example of the axial groove;
Figs.4, 5, 6 and 7 each show another example of the tread pattern according to the invention; and
Fig.8 shows a tread pattern outside the present invention used in comparison tests. In the drawings, the pneumatic tyre 1 is a radial ply tyre for passenger cars, of which the aspect ratio (tyre section height/width) is not more than 80 % in this example 65 %.

The tyre 1 comprises, as shown in Fig.1, a tread portion 2, a pair of sidewall portions 3, a pair of bead portions 4 each with a bead core 5 therein, a radial carcass 6 extending between the bead portions 4 and turned up around the bead cores 5 to be secured in the bead portions 4, and a belt 7 disposed radially outside the carcass 6 and inside the tread 2.

A central region Y1 of the tread portion 2 is provided with at least one wide circumferential groove M extending continuously in the tyre circumferential direction.

A pair of middle regions Y2 and a pair of shoulder regions Y3 of the tread portion 2 are not provided with any circumferentially continuously extending groove, but a plurality of axial grooves G.

As shown in Fig.2, the central region Y1 is defined between a pair of first circumferential lines X1 each drawn on each side of the tyre equator C at an axial distance L1 from the tyre equator C. The distance L1 is 0.125, times the ground contacting width TW of the tread portion 2. For the distance L1, a tolerance of plus minus 0.025 TW can be allowed. (L1 = 0.1 to 0.15 TW)

Each of the middle regions Y2 is defined between one of the first circumferential lines X1 and a second circumfer-

ential line X2 drawn at an axial distance L2 from the tyre equator C. The distance L2 is 0.35 times the ground contacting width TW. For the distance L2, a tolerance of plus minus 0.025 TW can be allowed. (L2 = 0.325 to 0.375 TW)

Each of the shoulder regions Y3 is defined as extending axially outwardly from the second circumferential line X2.

Here, the ground contacting width TW is defined as the maximum ground contacting width between the axial outermost edges of the ground contacting area Y when the tyre is mounted on its standard rim, inflated to its standard pressure (2.0kgf/sq.cm in this example), and then loaded with 70 % of the maximum load. As the standard rim a rim officially approved for the tyre by, for example JATMA (Japan), TRA (USA), ETRTO (Europe) and the like is used. Also the standard pressure and the maximum load are those specified by the same associations.

The wide circumferential groove M is centred on the tyre equator C, and the groove width W1 thereof is set in the range of from 0.05 to 0.15 times the ground contacting width TW. The wide circumferential groove M is independent, namely, no groove is connected thereto, and in this example it is a straight groove. Therefore, a big water drainage towards the front and rear directions is provided in the central region Y1. However, even if an air tube resonance phenomenon occurs because the groove M is wide, the resonance sound hardly leaks outside the tyre because no groove is connected to the wide groove.

In this embodiment as the aspect ratio is relatively low and thus the tread is wide, in order to provide additional drainage for the tread, the central region Y1 is further provided on each side of the wide circumferential groove M with a narrow circumferential groove m extending continuously in the tyre circumferential direction.

The narrow circumferential groove m is a straight groove, and the groove width W3 thereof is less than 0.05 times, in this example 0.02 to 0.035 times the ground contacting width TW.

Therefore, due to the narrow grooves the drainage from the central region Y1 is further improved without increasing the air tube resonance sound because an air tube resonance phenomenon hardly occurs in such a narrow groove.

The circumferential grooves M and m are preferably straight, but a gentle zigzag or wavy configuration may be used.

The axial grooves G extend across the whole width of the middle region Y2 and shoulder region Y3, and the inner end Gi of each axial groove G is connected to one of the narrow circumferential grooves m, and the outer end Go thereof is open to the tread edge E.

The axial grooves G have a relatively narrow groove width W2 of from 0.02 to 0.035 times the ground contacting width TW to preclude air resonance noise being generated.

When the narrow circumferential grooves m are not provided, the inner ends Gi are preferably terminated in the central region Y1 without connecting to the central wide circumferential groove M.

The main part G1 of the axial groove G which is defined as a part in the middle region Y2 intersect or cross the first circumferential line X1 at an angle θ1 of from 10 to 25 degrees and intersect the second circumferential line X2 at an angle θ2 of from 30 to 45 degrees.

In the example shown in Fig.2, the main part G1 is bent in the middle thereof so as to be composed of two straight segments. However, it is also possible to form the main part G1 with a smoothly curved single part as shown in Fig.3.

The outer part G2 of the axial groove G which is defined as the part in the shoulder region Y3 is inclined at an angle 3 of from 90 to 60 degrees, in this example 90 degrees with respect to the tyre circumferential direction. Accordingly, the axial groove G is bent at the line X2, forming an angle of 60 to 45 degrees.

In each of the middle regions Y2, the number of axial grooves G which is equal to the number of all the existing grooves (exclude sipes) is preferably set in the range of from 25 to 45 in case of passenger car tyres. If the number is less than 25, the improvement in wet performance is insufficient. If the number is more than 45, running noise increases.

In each of the shoulder regions Y3 in this example, a lug groove 10 is disposed between the axial grooves G, which lug groove 10 is substantially the same as the outer part G2 in respect of the width and inclination angle. Therefore, the number of all the existing grooves (exclude sipes) is doubled.

On each side of the tyre equator C, the axial grooves G are inclined in the same direction. In Fig.2, the inclining direction on one side is the same as the other side. However, the inclining direction on one side can be reversed to the other side as shown in Fig.4. The tread pattern shown in Fig.4 is otherwise the same as the pattern shown in Fig.2.

If the groove width W1 is more than 0.15 TW, the resonance noise is liable to leak. If the groove width W1 is less than 0.05 TW, the wet performances are greatly decreased.

If the groove width W2 is more than 0.035 TW, the noise is liable to increase. If the groove width W2 is less than 0.02 TW, the wet performances are greatly decreased.

As explained above, the inclination angle of the axial grooves G to the circumferential direction is relatively small in the axially inner part. Therefore, in and near the central region Y1, the axial grooves G function as a circumferential groove to improve drainage in this region.

Further, the inclination angle is larger in the axially outer part. Therefore, the groove line is akin to the actual flow line of the water discharged sideways from the tread centre, and the resistance to water flow is thus lower.

Furthermore, the middle and shoulder regions Y2 and Y3 are not provided with a circumferential groove, and the axial grooves G have a narrow width and an inclination angle. Accordingly, the occurrence of air tube resonance is

effectively prevented and then the pass-by noise is minimised.

Figs.5 and 6 show modifications of the tread patterns shown in Figs.2 and 4, respectively, wherein sipes 11 are disposed in the middle regions Y2 and optionally in the shoulder regions Y3. A sipe is a cut or slit having a width of not more than 1.5 mm and less than the width W3 of the narrow circumferential grooves m.

Each sipe 11 has two ends which are not terminated in the tread rubber but open to the above-mentioned grooves such as the circumferential grooves M and m, the axial grooves G and the lug grooves 10.

In each region which is surrounded by the circumferentially adjacent axial grooves G and the first and second circumferential lines X1 and X2 the shape of which is generally a parallelogram, the arrangement is such that the total length LC of the circumferential lengths Lci of all the sipes 11 therein, the total length LW of the axial lengths Lwi thereof, and the above-mentioned ground contacting width TW satisfy the following relationship:

$$0.7 \leq (LC+LW)/TW \leq 1.2.$$

If (LC+LW)/TW < 0.7, the generally parallelogram region is liable to become high in pattern rigidity and so deteriorate ride comfort. Further, edge effect decreases and good on-the-snow performance can not be obtained.

If (LC+LW)/TW > 1.2, the pattern rigidity becomes excessively low and the steering stability decreases.

The sipes 11 in Figs. 5 and 6 are straight in the middle regions Y2, but it is possible to bend the sipes as shown in Fig.7.

Comparison Tests

Test tyres all having the same internal structure shown in Fig.1 but different tread patterns were made by way of test, and the following tests were made.

1. Wet performance test

i. Aquaplaning test (cornering)

Running the test car on a 100 meter radius test course having a paved surface provided with a 20 meter length, 5 mm deep water pool, the lateral acceleration (lateral G) was measured increasing stepwise the running speed, and the average lateral G in the range of from 70 to 90 km/h was calculated.

ii. Aquaplaning test (straight running)

On a straight test course having a paved surface provided with a 10 mm deep water pool, the running distance to stop when full brakes were applied at a speed of 40 km/h was measured.

iii. On-the-snow performance test

Running the test car on a snowy road surface, the braking, starting and acceleration were evaluated by the driver's feelings. The results are indicated by an index based on that the tyre No.9 is 100. The larger the value, the better the performance.

2. Pass-by noise test

According to the "Test Procedure for Tyre Noise" specified in Japanese JASO-C606, the test car was coasted for a 50 meter distance at 60 km/h and 35 km/h on a straight test course, and the maximum noise sound level was measured with a microphone set at 1.2 meter height from the road surface and 7.5 meter sideways from the course.

3. Noise feeling test, Ride comfort test and Steering stability test

The test car was run on various road surfaces on a test course, and the performances were evaluated by the test driver's feelings. The results are indicated by an index based on that the tyre No.9 is 100. The larger the index, the better the performance.

The test results and tyre specifications are shown in the following Table 1.

Through the tests it was confirmed that the tyres according to the present invention were improved in both aquaplaning performance and pass-by noise.

TABLE 1

Test Tire No.	1	2	3	4	5	6	7	8	9
	Ref.1	Ex.1	Ex.2	Ref.2	Ex.3	Ex.4	Ex.5	Ex.6	Ref.3
Tread Pattern	Fig.2	Fig.2	Fig.2	Fig.2	Fig.5	Fig.5	Fig.5	Fig.5	Fig.8
Tread width TW (mm)	140	140	140	140	140	140	140	140	140
Center wide groove M									
Width W1 (mm)	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	
W1/TW ratio	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	
Narrow groove m									
Width W3 (mm)	4.2	4.2	4.2	4.2	4.2	4.2	4.2	4.2	
W3/TW ratio	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
Axial groove G									
Width W2 (mm)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	
W2/TW ratio	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	
Intersecting angle θ 1 (deg)	5	12	23	30	23	23	23	23	
Intersecting angle θ 2 (deg)	35	35	35	35	35	35	35	35	
No. of grooves									
Middle region	40	40	40	40	40	40	40	40	
Shoulder region	80	80	80	80	80	80	80	80	
Sipes in Middle region	none	none	none	none					none
Total circ. component LC (mm)					58	32	51	90	
Total axial component LW (mm)					68	38	61	106	
LC+LW					126	70	112	196	
(LC+LW)/TW					0.90	0.50	0.80	1.40	
Test results									
Wet performance									
Aquaplaning (cornering)	101	103	104	105	105	105	105	102	100
Aquaplaning (straight)	103	102	102	100	102	102	102	100	100
On-the-snow	98	100	100	101	108	102	106	106	100
Pass-by noise									
@ 35 km/h (dB)	-0.6	-0.8	-0.9	-0.6	-1.0	-1.0	-1.0	-1.1	0.0
@ 60 km/h (dB)	-0.7	-0.9	-1.0	-0.7	-1.2	-1.1	-1.2	-1.1	0.0
Noise feeling	103	102	101	98	103	102	103	102	100
Ride comfort	100	100	100	100	103	102	102	103	100
Steering stability	99	100	100	99	100	101	100	97	100
Tire size:	195/65R15								
Rim size:	15X6JJ standard rim								
Pressure:	Normal pressure of 2.0 kgf/sq.cm								
Test car:	2000cc passenger car with the test tires								
	mounted on all wheels								

Claims

1. A pneumatic tyre characterised by a tread portion (2) having a ground contacting width TW provided in a central region Y1 with a wide circumferential groove (M) having a groove width W1 of from 0.05 to 0.15 times the ground contacting width TW and extending continuously in the tyre circumferential direction where the central region Y1 is defined as being between a pair of first circumferential lines X1 one drawn on each side of the tyre equator (C) at an axial distance L1 from the tyre equator of 0.1 to 0.15 times the ground contacting width TW, wherein the tread portion (2) is not provided either in the middle regions Y2 and shoulder regions Y3 with any circumferential contin-

uously extending groove, but a plurality of axial grooves (G) each extending from the central region Y1 through one of the middle regions Y2 and one of the shoulder regions Y3 to one of tread edges (E), the axial grooves (G)having a groove width W2 of from 0.02 to 0.035 times the ground contacting width TW, the middle regions Y2 being defined as between the first circumferential lines X1 and a pair of second circumferential lines X2 one drawn on each side of the tyre equator at an axial distance L2 from the tyre equator C of from 0.325 to 0.375 times the ground contacting width TW, the shoulder regions Y3 each being defined as extending axially outwardly from each of the second circumferential lines X2, and the axial grooves (G) intersect the first circumferential lines X1 at an angle θ1 of from 10 to 25 degrees, and intersect the second circumferential lines X2 at an angle θ2 of from 30 to 45 degrees.

2. A pneumatic tyre according to claim 1, characterised in that the tread portion (2) is provided in the central region Y1 with a pair of narrow circumferential grooves (m) disposed one on each side of the wide circumferential groove (M), the narrow circumferential grooves (m) having a groove width W3 of less than 0.05 times the ground contacting width TW, and the axially inner ends (Gi) of the axial grooves (G) are connected to the narrow circumferential grooves.

3. A pneumatic tyre according to claim 1 or 2, characterised in that in the middle regions Y2, the number of axial grooves (G) is in the range of from 25 to 45.

4. A pneumatic tyre according to claim 1, 2 or 3, characterised in that the tread portion (2) is provided in the middle regions Y2 with sipes (11) having a width of not more than 1.5 mm, and in each region which is surrounded by the circumferentially adjacent axial grooves G and the first and second circumferential lines X1 and X2, the total length LC of the circumferential lengths of all the sipes therein, the total length LW of the axial length Lwi thereof, and the ground contacting width TW satisfy $0.7 \leq (LC+LW)/TW \leq 1.2$.

Fig. 1

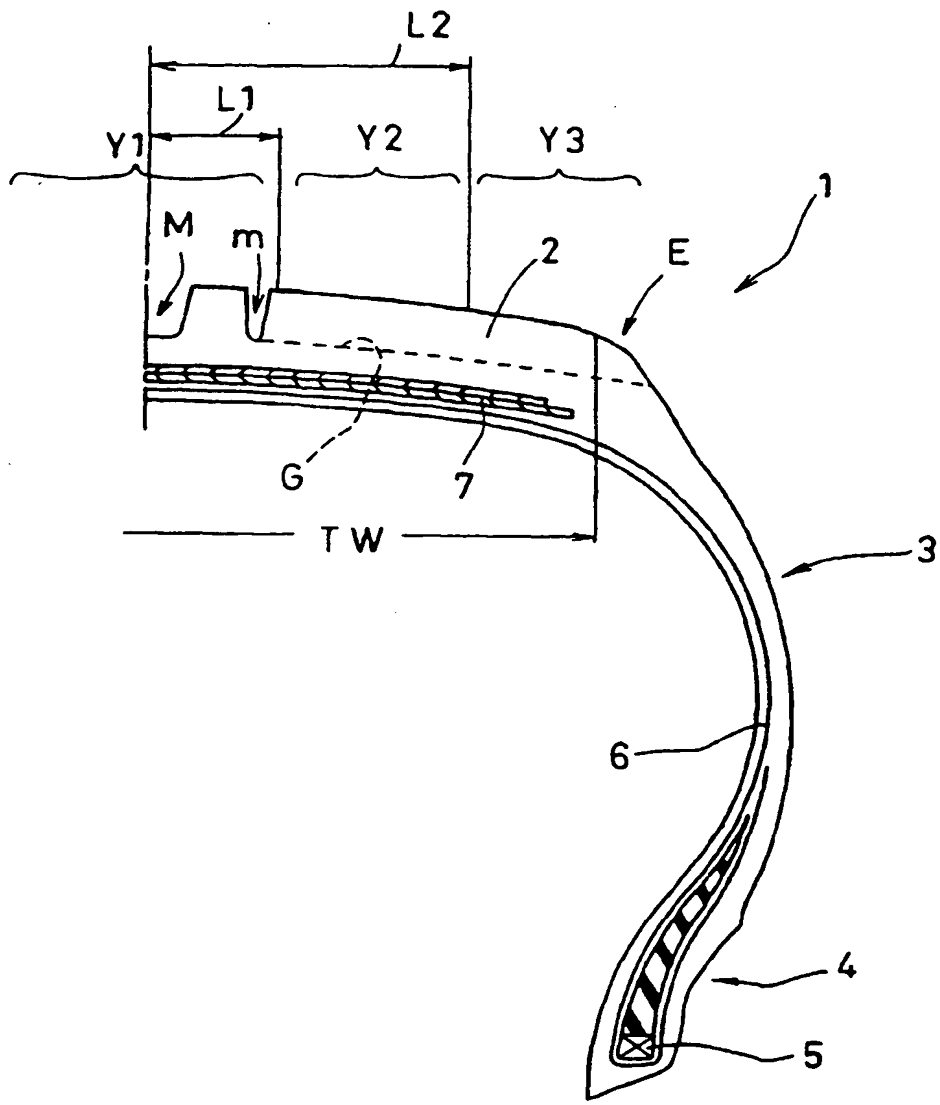
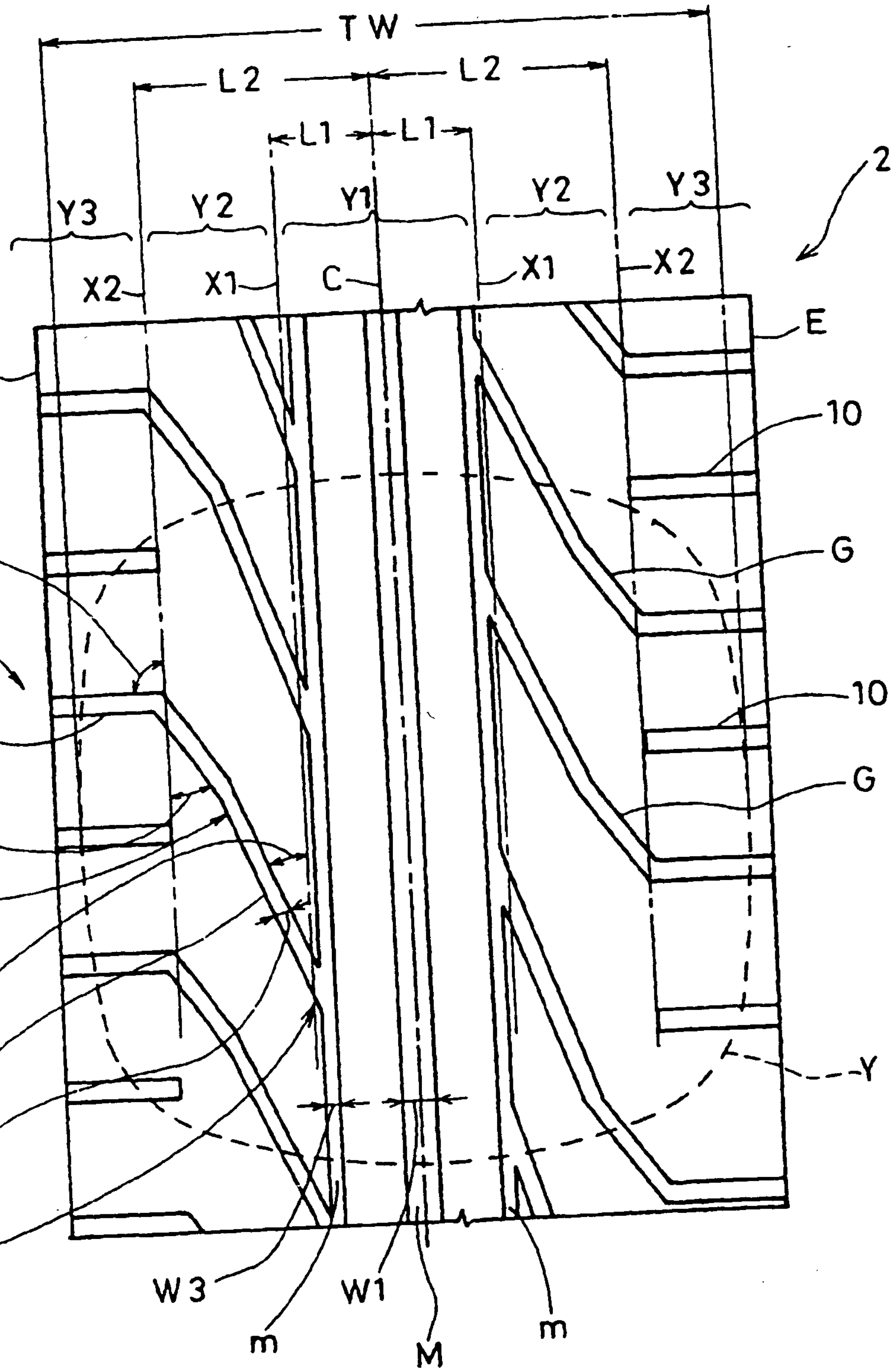


Fig. 2



TW
L2
L2
L1
L1
Y3
Y2
Y1
Y2
Y3
2
X2
X1
C
X1
X2
E
E
10
θ3
G
G0
10
G2
G
θ2
G
θ1
G1
Y
W2
Gi
W3
W1
m
M
m

Fig. 3

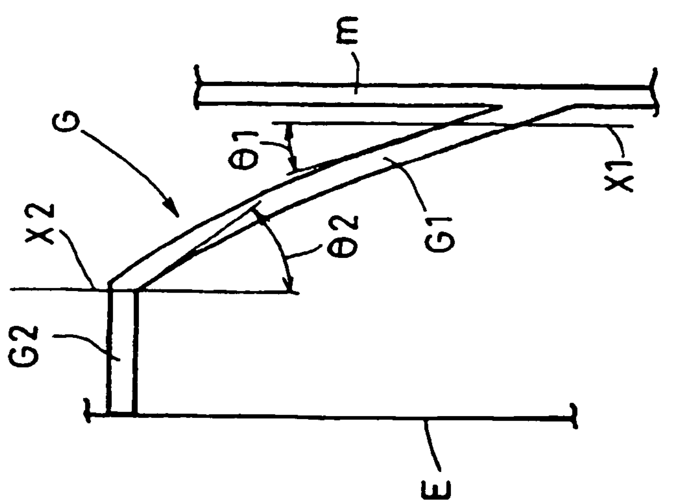


Fig. 4

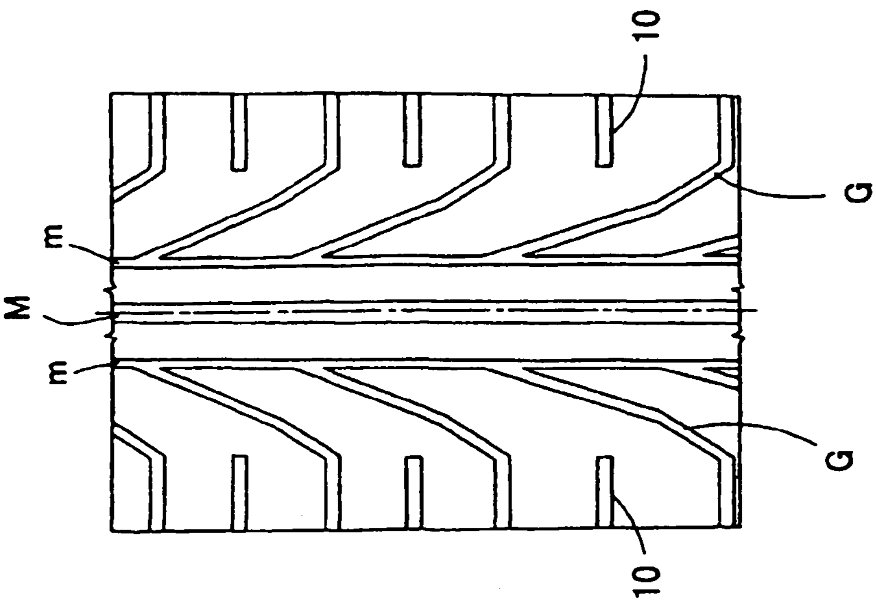


Fig.5

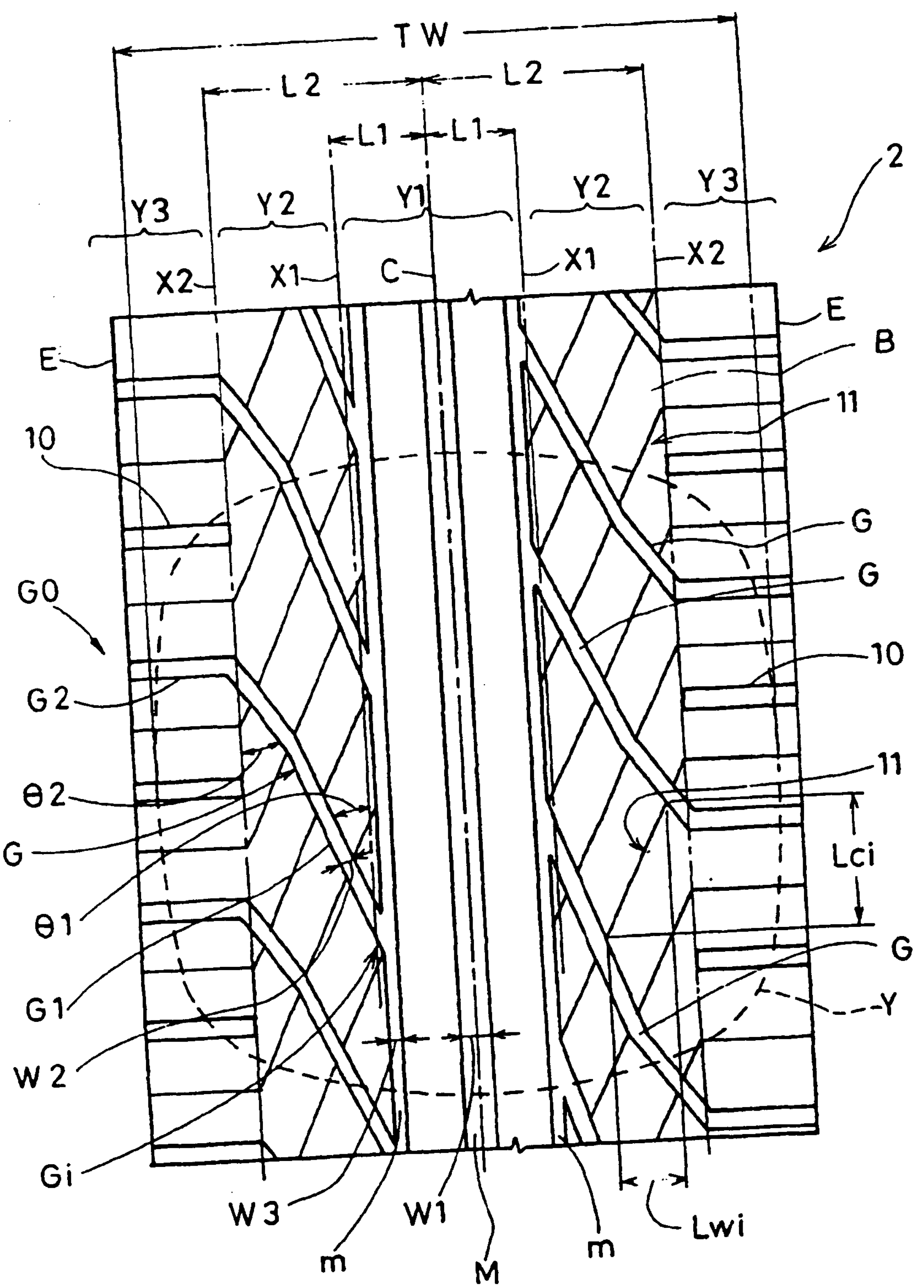

TW
L2
L2
L1
L1
Y3
Y2
Y1
Y2
Y3
2
X2
X1
C
X1
X2
E
E
B
10
11
G
G0
G
10
G2
θ2
11
G
Lci
θ1
G1
G
Y
W2
Gi
W3
W1
m
M
m
Lwi

Fig.7

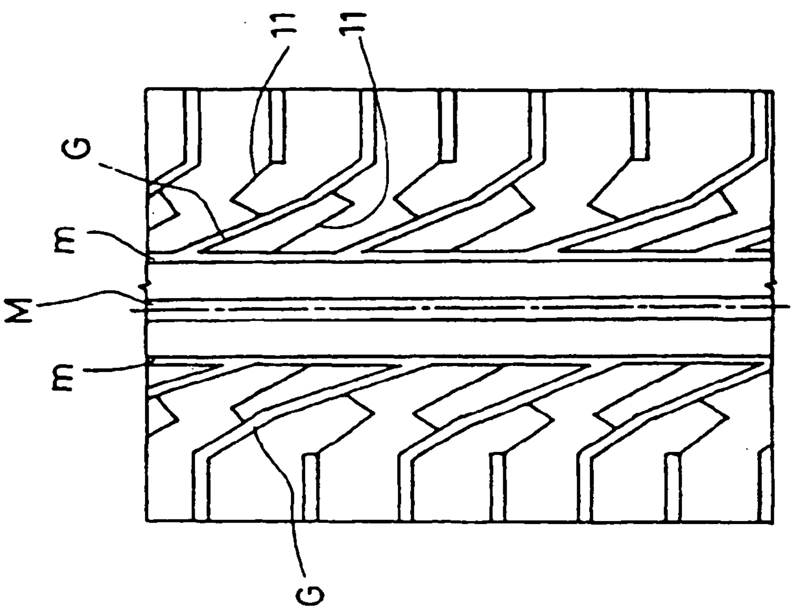


Fig.6

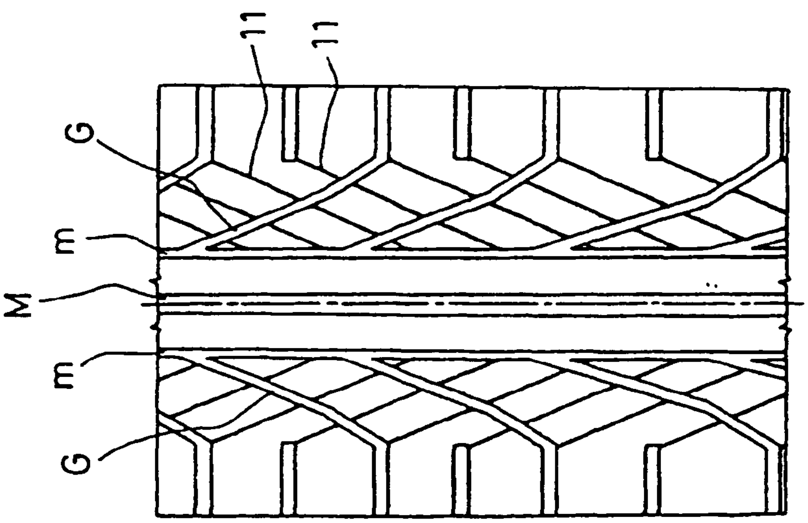
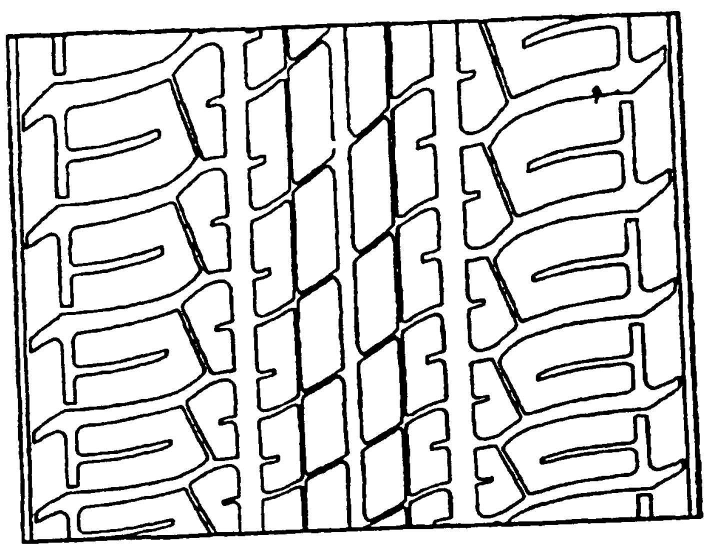


Fig. 8



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 9413

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	EP 0 588 781 A (SEMPERIT AG) 23 March 1994 * page 3, column 3, line 47 - column 4, line 49; claims; figures * ---	1	B60C11/00 B60C11/03 B60C11/04
Y	DE 37 07 953 A (BRIDGESTONE CORP) 15 October 1987 * page 3, line 56 - line 66; claims * ---	1	
A	EP 0 627 332 A (PIRELLI) 7 December 1994 * column 3, line 22 - line 55; claims; figures * * column 6, line 45 - column 8, line 18 * ---	1-4	
A	EP 0 488 740 A (BRIDGESTONE CORP) 3 June 1992 * page 3, line 42 - page 4, line 4 * * page 3, line 19 - line 27 * -----	2	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B60C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	18 April 1997	Baradat, J-L

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

THIS PAGE BLANK (USPTO)